FORMS OBSERVED IN WATER OF LAKE ERIE.

By C. M. Vorce, Cleveland, O.

Although all bodies of fresh water support myriads of minute forms of life and beauty, it is from the smaller bodies of water that most of the well-known forms are reported to be taken. Ponds, rivers, ditches, pools, and above all, swamps, are the great sources of supply as reported in the books. And in regard to all but the very minute forms it is probable that small, or at all events shallow waters are most favorable to their development. The littoral species do not find in bodies of water like the Great Lakes so favorable, nor, compared to the amount of water, so extensive grounds of habitation as in small still ponds or gentle streams. And the amateur collector when he first essays to reap the harvest to be found in a large body of water like Lake Erie, is pretty sure to come to the conclusion that it is rather barren hunting ground. Along the gravelly beaches of the lake one may wander for miles and find absolutely nothing to collect for microscopal study. About the rocks and piling in the neighborhood of cities, a few forms of algæ, diatoms, vorticellæ and Rhizopods are found, but chiefly the few species of algæ are the most that is to be found, although occurring in immense quantities. But when we achieve an examination of the forms living at large in the vast volume of water, we find it to teem with almost as busy life as the renowned "wayside pool," and to be really richer in the number of different forms than any pond, swamp or other smaller body of water. In the waters of the Great Lakes are found species which elsewhere are only recorded as shallow water forms, and at the same time species which are without doubt survivors of pre-historic seas. Here are gathered together forms descended from a marine ancestry, denizens of the present brackish waters, and

others born in the semi-warmed pools and tepid swamp waters, and poured by nature's vicissitudes into the great preserving reservoir, where, removed from the sudden and violent changes of their native habitat, they soon adapt themselves to the equable conditions of the great body of water, and, with probably some constitutional changes, flourish amain. It has come to be well-known, at least to most microscopists, that the waters of the Great Lakes abound in minute life, but little has been done, compared to the opportunity afforded, in the way of careful, constant and continuous scrutiny of the forms to be found in those waters, and the determination of the many problems connected with their being. Scarcely a dozen observers have given the matter much attention, and still fewer have devoted to the subject continuous observation. So little does casual observation reveal of what is to be learned, that, within a few years, a new and important diatom, found in the water of Lake Erie, was named by Prof. H. L. Smith, which had escaped the notice of many observers who had desultorily examined the contents of the water from time to time for years, and is not known to have been seen by more than one observer before it was described by Prof. Smith, and after it was published by him, months of careful search for that particular form were expended by several observers before it was again detected.

For several years prior to 1877 I casually examined the Lake Erie water, as did several others of my acquaintances, but without making or keeping any record of the forms observed. In that year (1877) I commenced keeping a record of the forms observed from time to time, which was not, however, complete, and it was not until 1879 that I made really systematic examination and records. During that year I made weekly examinations and noted the results, also comparing the same at times with the examinations made by others in different cities along the chain of lakes.

The observations were made upon filterings from the city water-supply of Cleveland, by tying a muslin bag over the house supply faucet and allowing a gentle stream to run through it until the pores of the cloth were clogged with the arrested organisms and the sack became full and turgid. The water was then shut off and part of the water allowed to ooze from the the sack, when it was removed and the contained organism rinsed out into a cup or conical vessel,

and allowed to settle. The observations in most cases were begun within a few minutes after the settling began, and were continued through an evening and frequently resumed the following morning.

One of the most noticeable results of the year's observations was the discovery that a well-marked periodicity existed in the appearance of certain forms, and that no similarity existed between the yield of lake forms and that from any other accessible body of water. And equally surprising to the writer was the discovery that the winter season was the most prolific of the whole year in number and variety of forms observed. The presence or absence of ice on the lake about the "crib," a mile from shore, where the water is taken into the supply tunnel, appeared to affect the character of the forms seen in the filtering, while winds did not, otherwise than to add more or less mud to the gathering. Sand was never observed, although it must enter the tunnel to some extent during storms, but settles before reaching the pumping station.

Aside from the variety of forms in the winter season, the peculiar nature of many of them gives rise to very interesting questions concerning the reasons for their abundance in such a habitat and at such season. The most noticeable peculiarity of the filterings taken at this season is the abundance of infusoria, rotatoria and crustacea, which in small bodies of water are warm-weather forms; and next in attracting attention is the remarkable activity of reproduction in vegetable life. Indeed, it is soon apparent to the observer that while the advent of wintry frosts almost suspends the course of growth and reproduction in most allied forms in small and shallow waters, in these vast watery worlds the course of life with these minute organisms goes unceasingly on without a rest, and with, indeed, no perceptible check or stay. When the change in volume is imperceptible, and the change in average temperature but a few degrees, there is for the forms in these great waters little or no need for nature to resort to "winter eggs" and "resting spores," although they are sometimes found, more, probably, from organic idiosyncracy than from climatic or local causes, such as chiefly contribute to cause such life changes in usual circumstances.

In the lake waters the advent of spring exhibits no other effect upon the organisms we are considering than to cause an acceleration of the processes of multiplication and reproduction in many of the

forms, so that these accelerated forms eventually become so much more numerous than the others that the latter are frequently looked upon as missing, although usually to be found if carefully searched for. In addition to this cause, the same effect is increased as spring advances and summer approaches, by the shallow water forms being swept in from the streams and continuing their reproduction in the lake waters. And in the cases where examinations are made from water supplies passing through storage reservoirs, the influence of the still water in the reservoir, and of its bottom of sluicy mud, is also to be considered.

As summer wanes and cold weather again approaches, the winter forms increase in activity and abundance, while the summer forms become more inactive, and the preponderance is again reversed.

From examinations made during several years up to and including 1879, I divided* the periodicity of the lake water forms into three conditions, viz., from about November 1st to about February 1st to 15th, a period of the greatest abundance of the scarcer or winter forms; from the first or middle of February to about May 1st, a period of the greatest variety of forms; and from about May 1st to about November 1st, a period of the greatest abundance (in amount) of the prevailing forms, which are then chiefly vegetable.

I should now be inclined to define the periodicity of forms as consisting of two great periods, viz., winter and summer, separated by transition periods in spring and fall, for I am now disposed to regard the numerical abundance of forms during the late winter and early spring, as produced chiefly by the beginning influx of warm weather forms among the still persising winter forms, most of which, I believe, are to be found, although in diminished numbers, throughout the summer, but are rendered inconspicuous by the abundance in quantity of the summer forms. The transition periods in spring and fall are, however, marked by the prevalence of forms which are not common either in winter or summer, and thus might support a division into four periods, corresponding to the four seasons of the year, were it not that these recurring forms are four in number, and common to both spring and fall, thus going apparently to indicate that the primary cause of the periodicity is temperature. If this be

* In Com. to Trans. Kirtland, Soc. Nat. Sciences, Feb. 16, '80.

the real cause it is singular at least that the desmids, lovers of the warm, sunny pools should be so abundant and actively multiplying in the dark, cold waters of the lakes in midwinter, and should be not more abundant during the warmer summer period.

For the purpose of exhibiting the characteristic forms of each of the periods observable, I undertook, in the late fall of 1880, to make systematic and continuous observations of the forms found in the lake water, and drawings of each form seen, intending to continue the work through an entire year, and by a series of plates, prepared as the observations might determine, to show the forms found and the time of their occurrence. After a number of examinations, the record of observed forms was commenced on December 25, 1880, when the winter period seemed to be fully established, which was judged of by the fact of a series of observations showing continuously the same forms for a period of two or three weeks. From this time until into February, 1881, daily observations were made and forms observed and recorded, careful search of every dip being made with mechanical stage, only fresh filterings examined, and only such forms as were observed more than once were figured in the plate. About February 6th the changes in forms observed began to be noticeable, and to avoid including forms belonging to the spring plate, the forms figured in Plate VII. were limited to those recorded up to January 22, 1881. As soon thereafter as possible the plate was prepared, and this with other matters prevented the completion of observations of the spring period, so that the plate accompanying this paper is the only completed link in the proposed series of observations, which, however, it is my purpose to resume at the earliest opportunity, and, if possible, to complete.

Passing now to a description of Plate VII., it may first be stated that all of the forms figured were observed in the living state, except Figs. 2, 4, 5, 7, 10, 37, 103, 150, 156 and 171, which, though dead, were obviously but recently living. To express the relative abundance of the several forms, the following symbols are used, viz.:

† Abundant. One or more seen in nearly every sample from each gathering.
‡ Very abundant. Many seen in every sample from each gathering.
* Common. Found in every gathering but not in every dip.
° Not common. Found in almost every gathering, usually more than once.
§ Rare. Found in not more than half of the gatherings.
‖ Very rare. Very few seen during the whole period.

The figures are described as follows:

Fig. 1. An encysted Vorticella. Very abundant and very active, the cilia and masticatory organs in full play, and the whole body often moving convulsively in its cyst. This form was seen in every field, often several in view at once; but what is its free or stalked form was not ascertained, as every effort to free it by rupturing the cyst was fatal to it, and when crushed its characteristics cannot be satisfactorily made out. ‡

2 *Anuræa stipitata*(?) Dead; several were observed, and also a few of what I believe to be the same species with a thick tapering rib on the back extending nearly half the length of the carapace (Fig. 110). All of these latter were living, though retracted and inactive. °

3 *Anuræa longispina*. Living and active. This rotifer, first named by Prof. D. S. Kellicott, is common all the year round in the water-supply of Cleveland, but is more plentiful in winter than in summer. *

4 *Vorticella sp.* (?) Dead. This vorticella in some particulars is very like the encysted form No 1, but seems considerably too large to be the same, while the free swimming form No. 6, although of about the same size as No. 1, does not at all resemble it. No. 149 is smaller than No. 6, and has the cilia differently arranged. No. 150 may be same as No. 1, but is more likely same as No. 6 or No. 149. *

5 *Rattulus*. (?) Several were observed but all were dead. °

6 *Vorticella sp.* (?) Free swimming. *

7 *Dinobryon sertularia*. Dead. ‡

8 *Vorticella sp.* (?) Living. °

9 *Paramecium*. (?) Living. *

10 *Epistylis* (?) But three specimens seen, all of which were dead. The stalk is not contractile, and the sheath, which is of a faint. yellow color, is flattened and the margin finely toothed. An allied form, No. 111, very much smaller and colorless, was also observed, but like the present form was only seen dead.

11 *Monas lens*. This form was seen sufficiently often to indicate that it inhabits the water of the lake or reservoir. It is not observed any more frequently in warm weather. °

12 *Hydra sp.* (?) Young and completely contracted. This form was at first supposed to be some species of naked rhizopod, as the body when contracted does not show folds nor do the arms or tentacles, which are five in number, exhibit when extended the rugæ or knobs usually seen in the tentacles of Hydra. Two specimens were observed, some days apart, in neither of which were the stinging cells noticed, the whole mass appearing granular and colorless like Amæba, but yet tough and fleshy. The tentacles, when extended as far as these were seen to protrude them, were of about the same length as the body. Transitional forms and mature specimens seen in later observations prove that this is some species of hydra.

13 *Spirrillum*. *

14 *Botryococcus*. (?) °

15 *Cyclops quadricornus*. In some gatherings Cyclops were so very abundant that it was necessary to strain the gathering through wire cloth to remove them in order to examine the smaller forms. The eggs, 182 a. b., in different stages of maturity were also abundant, but the young, No. 155, were only

Fig. moderately common, and the free clusters of eggs, No. 144, still less so. Cyclops are very rare in the filterings taken in summer. †

16 A very minute alga. (?) In tufts of very hyaline clavate branches. ‡

17 Same in later stage. (?) These forms are seen all the year round, in the same condition as here figured. No further advancement than the stage shown in Fig. 139 (if it be the same species) has been observed. ‡

18 *Clathrocystis.* *

19 *Palmella sp.* (?) *

20 *Dictyosphærium sp.* (?) *

21 *Botryococcus sp.* (?) *

22 Empty spore-cyst of (?) °

23 Older stage of No. 21. (?) *

24 Same, still older (?) *

25, 26 and 96 *Glœocapsa.* Same species. (?) °

27 *Merismopedia nova.* *

28 *Sarcina.* °

29 *Chlorococcus sp.* (?) *

30 *Anabæna flos-aquæ.* °

31 *Scenedesmus polymorphus.* *

32 *Scenedesmus sp.* (?) °

33 *Spirogyra.* °

34 *Nostoc.* Or *spirillum.* (?) °

35 *Anabæna sp.* (?) °

36 *Anabæna gigantea.* °

37 *Brachionus sp.* (?) Dead. ‖

38 *Palmella.* °

39 A minute filamentous alga. ‖

40 *Microcoleous sp.* (?) The forms of alga from No. 18 to 40 inclusive are found in varying numbers throughout the year. Most of them are more plentiful in summer. No. 30 is seen on the waters of Sandusky Bay in August in such quantity as to line the shores with a film of yellowish green scum for miles. No. 27 is also excessively abundant, while No. 33 is more common in the water supply. †

Fig. 41 Apparently the beginning of some filomentous form, but no more advanced state has been detected. Very rare in winter. °

42 *Actinophrys sol.* °

43 *Closterium sp.* (?) Has the exact shape of a pair of cow's horns. *

44 *Closterium venus.* Spirally bent. *

45 *Closterium dianæ.* *

46 *Pediastrum sp.* (?) *

47 *Pediastrum sp.* (?) *

48 *Pediastrum granulatum.* *

49 *Pediastrum boryanum.* *

50 *Staurastrum gracile.* *

51 *Closterium Griffithsii.* *

52 *Closterium angustatum.* *

53 *Closterium lunula.* *

54 *Closterium setaceum.* The desmidiaceae, Nos. 43 to 54 inclusive, occur in greatest profusion in winter, although most of them are found throughout the year. °

55 *Stephanodiscus niagaræ.* Occurs throughout the year, but never abundant in summer, while in winter it often forms the bulk of the gathering. †

56 *Cyclotella kutzingiana.* *

57 *Cyclotella meneghiniana.* *

58 *Cyclotella sp.* (?) Very minute and flat. These three forms of cyclotella occur throughout the year; most abundant in winter, but quite common in summer. *

59 *Asterionella formosa.* ‡

60 *Tabellaria fenestrata.* These two forms continue abundant till early fall. †

61 *Rhizosolena eriensis.* *

62 *Fragilliara crotonensis.* Common throughout the year, and at times abundant for short periods, usually in summer or fall, *

63 *Fragillaria capucina.* *

64 *Melosira sp.* (?)

Fig. 65 *Melosira crotonensis.* Very abundant in fall, and more or less common during all the year. No. 64 is probably but a variety of this. *

66 *Synedra longissima.* *

67 *Synedra ulna.* *

68 *Nitzschia sigmoidea.* °

69 *Pleurosigma spenceri.* These four diatoms are found throughout the year, varying but very little in frequency of occurrence. °

70 *Encyonema cæspitosum.* °

71 Same, var. (?) °

72 *Cymbella cuspidata.* °

73 *Encyonema prostratum.* °

74 Same, var. *

75 *Navicula pelliculosa.* (?) §

76 *Navicula cryptocephala.* °

77 *Navicula amphigomphus.* (?) §

78 *Fragillaria acuta.* *

79 *Amphora ovalis.* °

80 *Amphora ovalis, var. minutissima.* °

81 *Surirella panduriformis.* °

82 *Tryblionella.* (?) §

83 (Not surirella. ?) °

84 *Amphiprora ornata.* b. side view. °

85 *Cymatopleura solea.* Long form. s. v. *

86 Same. front view. °

87 *Cymatopleura hibernica.* °

88 *Cymatopleura elliptica.* f. v. °

89 Same. s. v. °

90 *Surirella striatula.* §

91 *Surirella turgida.* °

92 *Tryblionella.* (?) §

93 *Cocconeis sp.* (?) °

94 *Cyclotella kutzingiana.* dividing. *

95 *Navicula limosa.* §

96 See No. 25. These may be Gonium sp. (?)

97 These eggs (?) have pulsating movements of the globules similar to the eggs of Cyclops, which they very much resemble except in the elongated shade. An occasional spasmodic movement is seen very similar to those of the encysted Vorticula, Fig. 1.

98 & 135 *Chlorococcus.* (?) °

99 Shell of *difflugia sp.* (?) °

100 *Acanthocystis sp.* (?) Has a tough membranous sac, while No. 42 has not.

101 & 102 Imperfect or unsilicified state of Epithemia(?) Several of these seen, but no perfect forms of Epithemia. These forms, as also No. 170, are not affected by nitric acid, and from their appearance would hardly be taken for anything else than diatoms, but the markings of Eunotia or Epithemia should be plainly made out, which cannot be done on these objects, even with 1/3 in. objective.

103 Cuticle of some water-plant. §

104 *Cyclidium elongatum.* ‖

105 *Trichodina pediculus.* §

106 *Monas attenuata.* §

107 *Anuræa sp.* (?) Resembles No. 174 except in unusual number of spines. ‖

108 Rhizopod. No more than one pseudopod observed in any specimen. §

109 (?) Has slow circling movement on a fixed pedicle, but no cilia discovered. §

110 *Anuræa stipitata.* (?) Has a strong dorsal rib on the carapace. §

111 Resembles No. 10, but vastly smaller. ‖

112 *Spirillum.* Very active. °

113 *Bosmina longirostris.* A heart. *

144 *Spirogyra.* (?) Contents granular. §

115 Spicula of Spongilla. Two forms, another form with a knob in the center is occasionally seen. These spicula are found at all seasons in the water supply; but no observer in Cleveland has °

Fig. yet been able to find Spongilla in the waters of Lake Erie.

116 *Bacillus. sp* (?) °

117 *Surirella biseriata.* 2 forms. °

118 *Cymbella cuspidata.* Very deformed. §

119 *Navicula inflata.* (?)

120 *Navicula sp.* (?) *

121 *Cocconeis pediculus.* °

122 *Cymatopleura solea.* Broad form. °

123 *Tabellaria flocculosa.* °

124 *Cymbella affinis.* °

125 *Navicula.* f. v. dividing. *

126 *Cyclotella rotula.* (?) with ring. §

127 Same. Complete frustule, dividing. §

128 *Vibrio* (?) (Near No. 67.) °

129 Gonidia of Pediastrum. †

130 *Protococcus sp.* (?) †

131 *Chlorococcus sp.* (?) *

132 *Cœlosphærium sp.* (?) °

133 Alga. Very pale, with bright green vesicles filled with granular contents. ‖

134 Same as No. 114? §

135 Same as No. 98, but more advanced. §

136 *Scenedesmus quadricauda.* (Near 33.) °

137 (?) Very pale green, and not granular. °

138 *Vibrio sp.* (?) °

139 Alga. (No. 17 more advanced?) About half of the branches have acquired a bulbous or clavate tip. °

140 *Glœocapsa ampla.* *

141 *Pediastrum sp.* (?) *

142 *Staurastrum digitatum.* °

143 Older stage of No. 19 (?) *

144 Eggs of cyclops *quadricornis.* *

145 *Spirillum.* (Near No. 7.) *

146 *Acomia.* (?) Flattened, cilia confined to the front part (¼ or ⅓) of body. °

147 Rhizopod.(?) A conical, unciliate, granular mass, crawling like amæba, but without changing its shape. The movement is more like flowing than crawling, and is quite slow; the granular mass seems to revolve, but maintains its shape and moves in the direction of the larger end. No vibration or undulation of the attenuate extremity can be perceived. The form, Fig. 177, resembles this one closely, but is composed of vesicles rather than granular matter, and is much more active. No. 178 is granular and sluggish, and moves in the direction of the two pointed processes, with the same flowing movement, but preserving its shape. It may be that a very fine flagulum terminates the two processes of Fig. 178; if so, it would be allied to Hexamita of Dujardin.

148 *Paramecium.* In conjugation. *

149 *Vorticella.* Different from No. 6. °

150 Same as last. (?) Encysted. dead. °

151 *Brachionus sp.* (?) *

152 Not Vorticella. It is flattened like Fig. 153, but revives rapidly by means of its long cilia, and revolves with a helical motion as it swims. °

153 *Gastrochæta.* Slow moving. °

154 *Vorticella sp.* (?) The rim is very mobile, and constantly its shape; cilia not entirely surrounding the rim. °

155 *Cyclops quadricornis.* Newly hatched. *

156 Shell of *Cypris.* §

157 *Anguillula fluviatilis.* °

158 *Anguillula.* (?) Encysted and moving restlessly in its sac, making obvious efforts to escape. Only one specimen seen, but the same form has been noted by others.

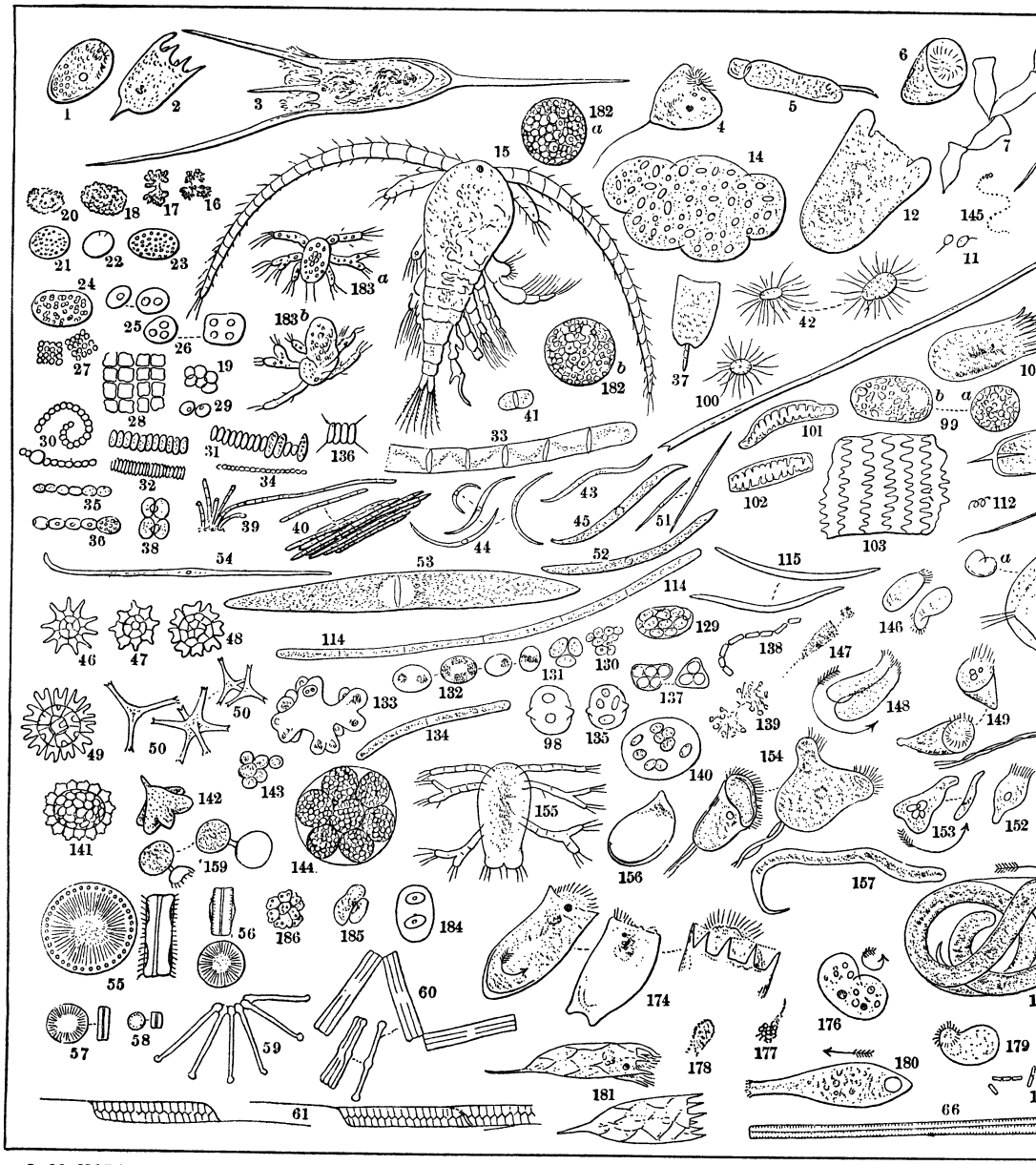
159 Spores and empty spore-cyst of. (?) §

160 *Melosira.* °

Fig. 161 *Stephanodiscus niagaræ*, sporangial frustule. (?) Very thin and flexible. °
162 Sporangium of a *navicula sp.* (?) §
163 *Actinocyclus niagaræ.* f. v. & s. v. §
164 *Pleurosigma sp.* °
165 *Cyclotella* sporangium. (?) See 94. °
166 *Cyclotella kutzingiana.* Deformed valve. ‖
167 *Navicula rhomboides.* §
168 *Amphora gigas.* §
169 *Surirella.* §
170 *Eunotia.* Imperfectly silicified. (?) §
171 *Daphnia pulex.* Dead. °
172 *Surirella.* (Same as 169.) Very active. b, end view. §
173 *Navicula sp.* (?) (Same as 120.) °
174 *Anuræa sp.* (?) *
175 *Anuræa.* Larger than No. 2 and without the dorsal rib of No. 110. *
176 *Paramecium.* Conjugation complete. °

Fig. 177 & 178 Both rare. See No. 147.
179 *Acomia sp.* (?) *
180 *Enchelys pupa.* Very active. §
181 *Anuræa sp.* (?) *
182 Eggs of cyclops in different stages. ‡
183 Young cyclops artificially hatched from the egg, 182 b. a dorsal. b. ventral view.
184 *Glœocapsa.* (?) The Enclosed bodies are yellow, and closely resemble Cocconeis. §
185 Conjugating cells of *coccochloris.* (?) °
186 Gonidia of *Pediastrum.* Advanced state. *
187 *Navicula pusilla.* (?) °
188 *Epithemia gibba.* *
189 *Epithemia gibba var. parallela* °
190 *Navicula gastrum.* °
191 *Melosira varians.* °
192 *Cymbella pediculus.* Parasitic on synedra, and very firmly attached. §

PLATE VII.



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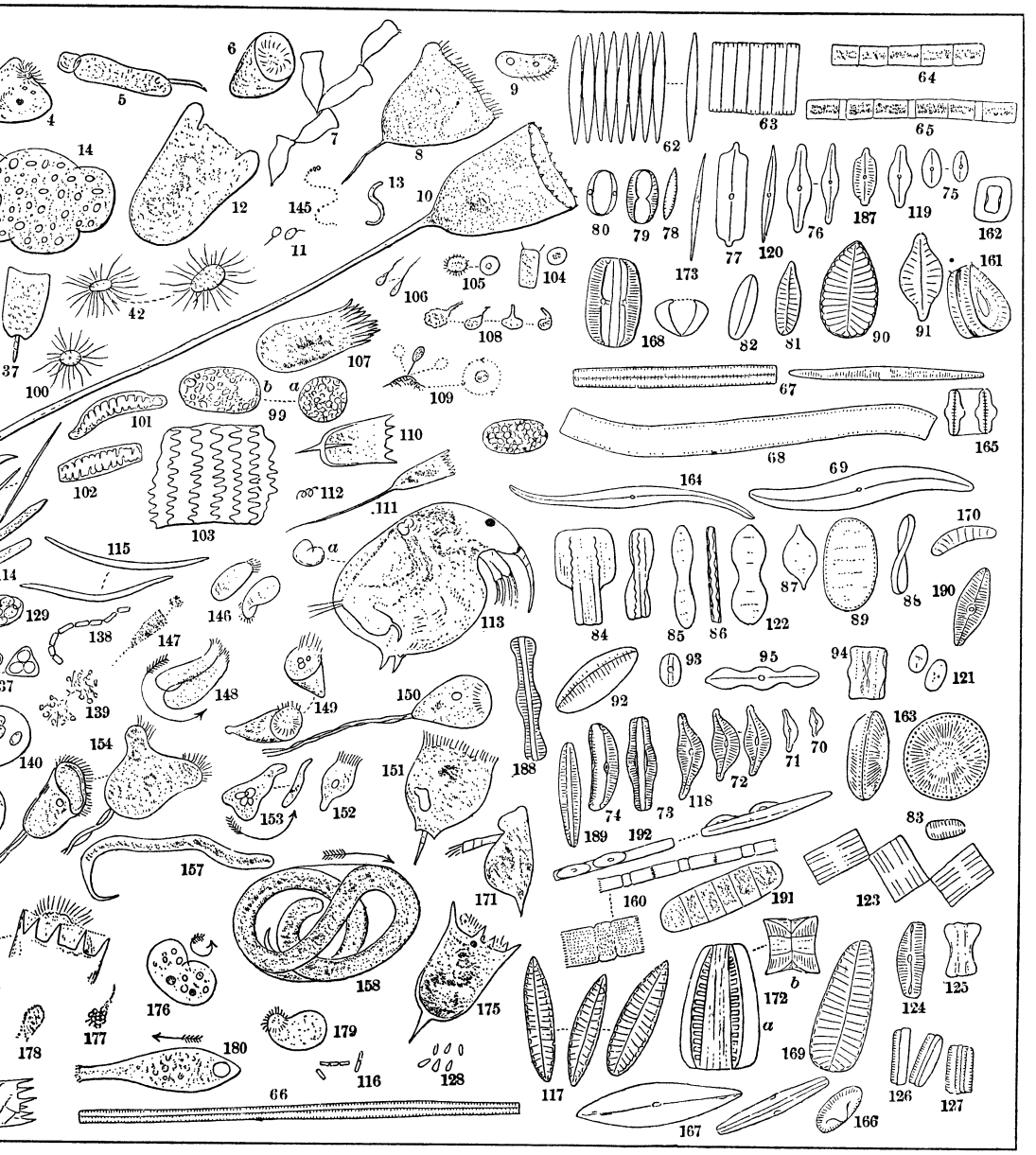

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